DEEP-SEA FISHES OF THE BERMUDA OCEANOGRAPHIC EXPEDITIONS

FAMILY NESSORHAMPHIDAE[1]

WILLIAM BEEBE

(Figs. 10-22 incl.)

CONTENTS

INTRODUCTION

All of the remarks in the Introduction to the preceding paper on the family Derichthyidae apply also to the present account. They will be found on p. 1 of this volume.

FAMILY NESSORHAMPHIDAE Schmidt 1931

Body anguilliform, slender, more or less cylindrical anteriorly but with caudal region rather compressed; anus behind middle of length; scales absent; lateral line with distinct pores; snout very long, flattened, spatulate, projecting far beyond the narrow lower jaw, its tip enlarged and holding the olfactory sac; anterior nostril terminal, posterior slightly behind it, dorso-

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lateral; neither nostril tubular; teeth conical, cardiform, in bands on both jaws, on vomer proper and on intermaxillary extension of vomer; tongue scarcely or not at all free anteriorly; branchial apertures widely separated slits of moderate size, inserted immediately in front of the well developed pectorals; dorsal beginning behind head, far in advance of anal; dorsal and anal confluent with caudal, which is short but well developed. One genus.

Genus **Nessorhamphus** Schmidt 1930

With the characteristics of the family. One species described; the Indo-Pacific forms may, however, prove to be distinct. General range: The warmer and saltier parts of the Atlantic, Indian and Pacific Oceans.

Nessorhamphus ingolfianus Schmidt 1930 (Schmidt 1912)

Specimens Taken by the Bermuda Oceanographic Expeditions

Twenty-one specimens; April to September, 1929 to 1931; 400 to 1,000 fathoms; from a cylinder of water eight miles in diameter (five to thirteen miles south of Nonsuch Island, Ber-

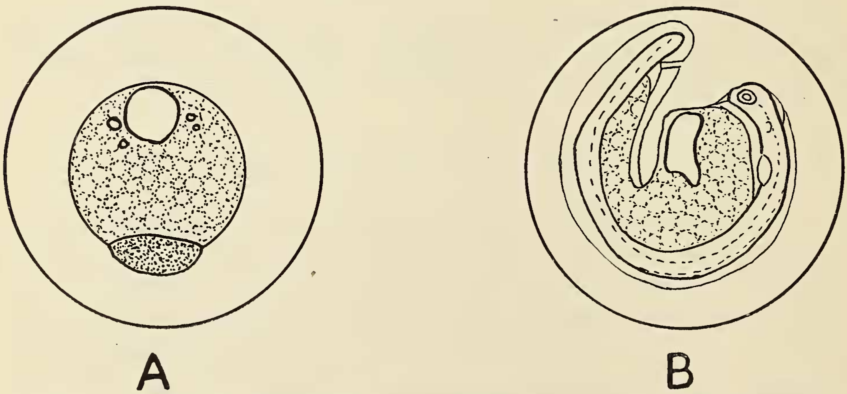


Fig. 10. Stages in the development of *Nessorhamphus ingolfianus*. A, egg, early stage; B, egg, late stage. (Both x about 16; after Táning, in Schmidt 1930).

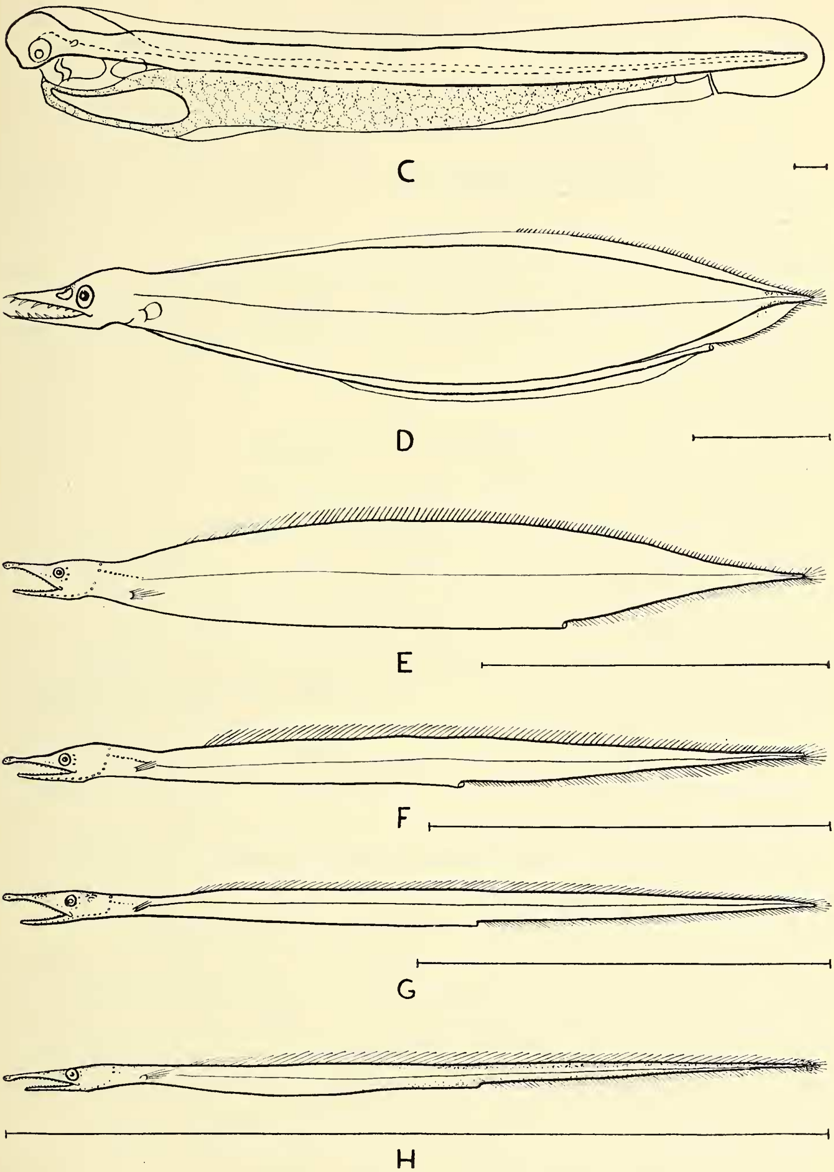


Fig. 10 (continued). Stages in the development of *Nessorhamphus ingolfianus.* C, Prelarva, 3 to 5 hours old; D, larva, 28 mm.; E, post-larva, 69 mm.; F, adolescent, 81 mm.; G, transitional adolescent, 92 mm.; H, transitional adolescent, 166 mm. The relative size of the specimens is indicated by the straight lines. (C, after Táning, in Schmidt 1930; D-H incl., from specimens taken by the Bermuda Oceanographic Expeditions).

muda), the center of which is at 32° 12′ N. Lat., 64° 36′ W. Long.; standard lengths from 26 to 166 mm.

Specimens Previously Recorded

Many thousands, the majority young and immature forms, were taken by the Danish research vessels within the past twenty years. Dr. Schmidt only found time, however, to publish brief preliminary descriptions. The eggs and smaller larvae were found to be pelagic, and the older forms bathypelagic. Range: Warmer parts of North Atlantic. Length: Egg to 248.5 mm., the type specimen.

Description of Adult

Color: Brownish, sides with bluish tinge.

Proportions: Depth in length 30 (small specimens) to 25 (large specimens); head in length 6 to 7.2; eye in head about 10.6; snout in head about 2.4; snout to dorsal origin in length 4.6 to 4.8; snout to anal origin in length about 1.8.

Teeth: Conical, cardiform; maxillary and mandible with narrow bands formed of from one to four irregular, broken rows of teeth, the band being single-rowed only in the extreme posterior part of the jaw, a maximum of 60 to 90 teeth in each row; a patch of similar teeth, about 35 or 40, on the intermaxillary extension of the vomer, and, posterior to these after an interval, an elongate patch on the vomer proper; the latter series are the last to develop; in the large, type specimen they number more than 100 according to Schmidt's figure (1930, pl. IV).

Fins: Pectoral rays 13, at least six times as long as eye in perfect examples, but usually broken; dorsal rays 276 to 291, the rays longest on the caudal peduncle, opposite the middle section of the anal fin; dorsal origin less than a snout's length behind pectoral base; anal rays 160 to 175, the rays much shorter than those of the dorsal; caudal fin truncated, continuous with dorsal and anal.

Pores and Lateral Line: Head with conspicuous mucous pores; fine parallel ridges near tip of snout and before and behind eye. About 132 pores in lateral line, which commences above the mid-line, but coincides with it from about the middle of the length posteriorly.

BRANCHIOSTEGALS: 6 to 7.

MYOMERES AND VERTEBRAE: 150 to 159 (72 to 73 pre-anal).

OSTEOLOGY; DIGESTIVE SYSTEM: Descriptions of these as they occur in slightly immature specimens commence on p. 37.

DEVELOPMENT

MATERIAL: The Bermuda collection consists of all stages from moderately young larvae to large transitional adolescents. Eggs and pre-larvae were described in Dr. Schmidt's paper by Dr. Tåning (1930, p. 275) and his description will be quoted below, so that the various growth stages of this eel will be completely summarized in the present paper. We do not know, however, whether the 248.5 mm. type specimen was fully mature. The Bermuda material is distributed as follows:

Larvae: 26, 28 mm.—2 specimens (Figs. 10D, 11A).

Post-larvae: 68 to 72 mm.—5 specimens (Figs. 10E, 11B).

Adolescents: 78, 81 mm.—2 specimens (Figs. 10F, 11C).

Transitional Adolescents: 80 to 166 mm.—12 specimens (Figs. 10G, 10H, 11D, 11E).

KEY TO THE GROWTH STAGES:

A. Body leptocephaloid (depth in length not more than 22; usually very much less); no general pigment on body.
  B. Larval teeth present; snout scarcely or not at all prolonged beyond mandible; anal origin far back, at 118th to 121st myomere .... *Larva*
  BB. Larval teeth absent; snout showing characteristic shape and prolongation.
    C. Anal origin not in final position, but located between about 116th and 76th myomeres; depth in length 7.4 to 9.6.. *Post-larva*
    CC. Anal origin in final position, between 74th and 72nd myomeres; depth in length 18 to 20...... *Adolescent*

AA. Body anguilliform (depth in length 29 or 30); general pigment appearing on body.................... *Transitional Adolescent*

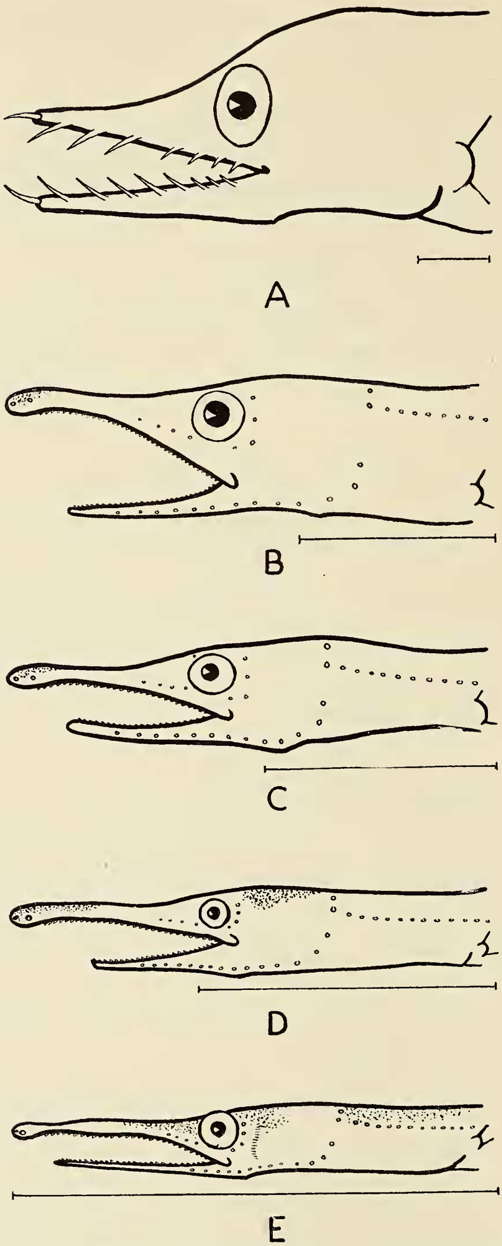


Fig. 11. Heads of *Nessorhamphus ingolfianus.* A, larva, standard length 28 mm.; B, post-larva, standard length 69 mm.; C, adolescent, standard length 81 mm.; D, transitional adolescent, standard length 92 mm.; E, transitional adolescent, standard length 166 mm. The relative size of the specimens is indicated by the straight lines.

(In fully pigmented, large specimens the body evidently, as is usual, becomes secondarily deeper, the depth being contained according to the type description only about twenty-five times in the length.)

Egg and Pre-Larva (From Tåning's description, Schmidt, 1930, p. 275) : "The egg is a typical, highly transparent, floating muraenoid-egg with a wide perivitelline space; vitellus nearly colourless with a light tinge of yellow. The membrane of the egg is for a deep-sea muraenoid-egg rather thick. Vitellus vesicular with one large oil globule, which at a very early stage in development—prior to advanced cleavage of the germinal disc—is a cluster of small oil-globules. The size of the egg is: Diameter 2.4-2.70 mm., vitellus 1.20-1.35 mm. and oil globule 0.42-0.48 mm. [see Figs. 10A, B]. The pre-larva, which leaves the egg at an early stage (abt. 7 mm.) has the oil globule situated anteriorly in the yolk-sack; in this stage it has abt. 84 abdominal segments. Pigment not present.

"In the Sargasso Sea the eggs were found in large quantities, especially numerous about May.

"The eggs resemble to a high degree those of the muraenoid fish to which *Leptocephalus anguilloides* Schmidt 1916 belongs. The eggs of this species are however smaller (less than 2.40 mm.) and have a larger vitellus (1.50-1.65 mm.), with accordingly a smaller peri-vitelline space."

The following résumé of the changes occurring during growth is based only upon the Bermuda material; where comparison was possible from the short description of the larva and from the series of photographs, the present specimens checked perfectly with corresponding ones in the Danish collection. A table of proportions will be found on p. 47.

Larva: The two larvae, 26 and 28 mm. in length, are typical leptocephali. Pigment is present only on the tail, in an irregular series of tiny chromatophores in and near the mid-line, and sparsely along the posterior parts of the fin bases. The larva is moderately deep; the tail tip rather attenuated; the head fairly small; eyes vertically elongate, larger than in succeeding stages; snout long, but no longer than the mandible; the latter already shows its characteristic narrowness. The nostrils are located

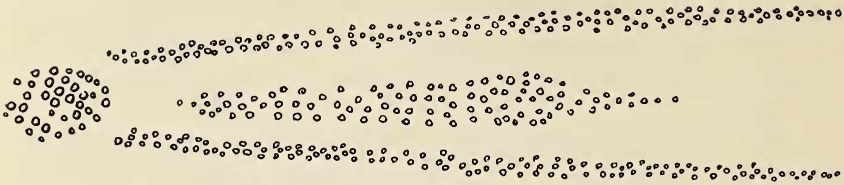


Fig. 12. *Nessorhamphus ingolfianus.* Dentition of upper jaw in transitional adolescent, standard length 142 mm. (x 11).

just in front of the eye. The larval fangs number eight pairs in the upper jaw and nine in the lower; in the maxillary the last four teeth on each side are much smaller than the anterior ones; in the mandible the same is true of the last three pairs. The pectoral has the usual fleshy base, fringed with raylets. The bases of both dorsal and anal fins are elevated, the rays not yet well enough developed to be counted with accuracy. The gut ends and the anal commences far back, on the posterior tenth of the body, lying between the 118th and 121st myomeres. The dorsal is traceable almost as far forward as the middle of the length. The caudal rays are well developed. Cephalic and lateral pores are invisible. The gut, suspended below the body wall, is entirely unpigmented; it is a simple tube with the anlage of the liver and other organs barely appearing.

Osteology: (Figs. 13, 14, 15). These larvae of course show no trace of ossification, but the principal cartilaginous elements of the head are traceable even in the unsectioned, preserved specimens, and are full of interest. The chief difference between the heads of larva and adult lies in the proportions of the chondro-cranium: the nostrils, as noted above, are situated not terminally, but close in front of the orbits. The frontals, fused even at this early stage, do not enter into either the roof of the snout nor that of the skull proper, being confined to the interorbital region. The future growth of the snout tissue will hence take place chiefly in the now narrow area between nostril and orbit, through the anterior projection of the frontals and posterior growth of the ethmoid, so that eventually the nostrils will be thrust far forward. As in the mature fish, the parietals are large and well marked. A relatively large supraoccipital can be traced. The otic region is not yet differentiated into epiotics and pterotics, but occupies the entire posterior and lateral portions of the brain-case. Viewed from above, the two epiotic regions diverge posteriorly from the supraoccipital into large wing-like processes.

All of the elements of the palato-pterygoid, jaw and opercular apparati are discernible and differ from the corresponding bones of the adult only in their typically immature lack of shapeliness and their general tendency to robust stockiness. The opercular apparatus in particular shows generalized characters, the opercle being fan-shaped, bounded ventrally and posteriorly by the broad subopercle. As in generalized fish also, the entire apparatus does not extend behind the vertical from the posterior margin of the brain-case, while in the adult it projects much farther. In the larva, too, a well defined gill opening appears in its normal place, beneath the gill flap formed by opercle and subopercle. The hyoid apparatus likewise has the elements of the adult, save that no branchiostegal rays are visible. The ceratohyal arises relatively farther back along the glossohyal.

The branchial apparatus has the rudiments of the two hypobranchials, five ceratobranchials and four epibranchials of the adult, but the pharyngobranchial elements are only questionably identifiable. The generalized shape of the gill arches is apparent, all of them being vertical and consecutive, and all are crowded beneath the broad main column of the hyomandibular and the region immediately behind—far forward of their subsequent location in the "neck" of the metamorphosed eel.

POST-LARVA: The post-larva is slightly more slender than the larva, larval teeth are missing and permanent teeth appearing, the snout assumes its characteristic configuration, with the nostrils approaching ever closer to their final position, and—an invariable character of this stage among the Apodes—the anus and anal fin are in the act of moving forward, and lie somewhere between about the 116th and the 76th myomeres. The rays are easily countable at this stage, but are relatively short, with their bases still elevated. The same applies to the dorsal rays, which have also migrated, so that before the end of the post-larval stage the fin originates in its final position back of the head. The cephalic pores are now discernible. The gut is almost completely enclosed within the body cavity.

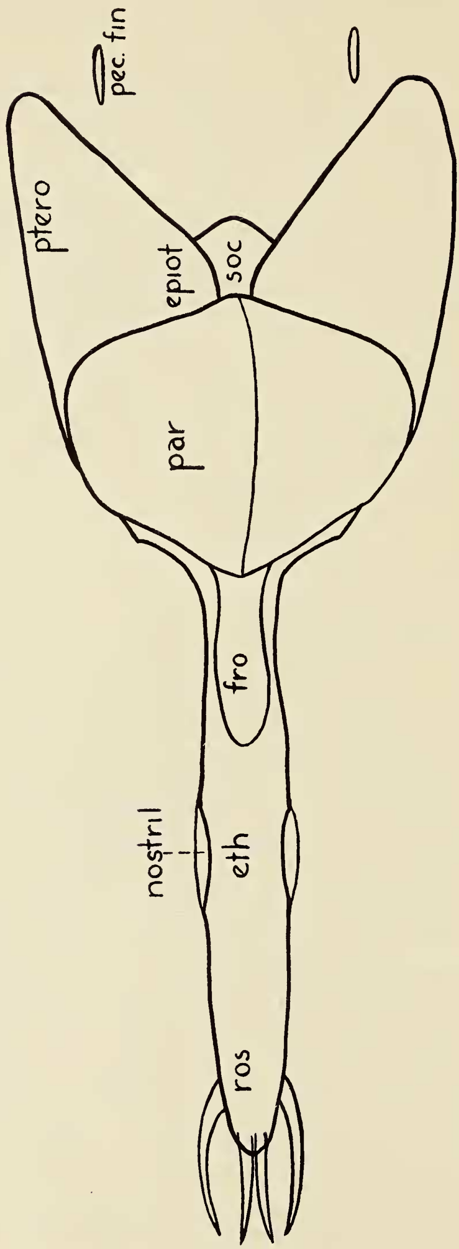


Fig. 13. *Nessorhamphus ingolfianus.* Skull of larva, standard length 28 mm.; dorsal view. (x 42).

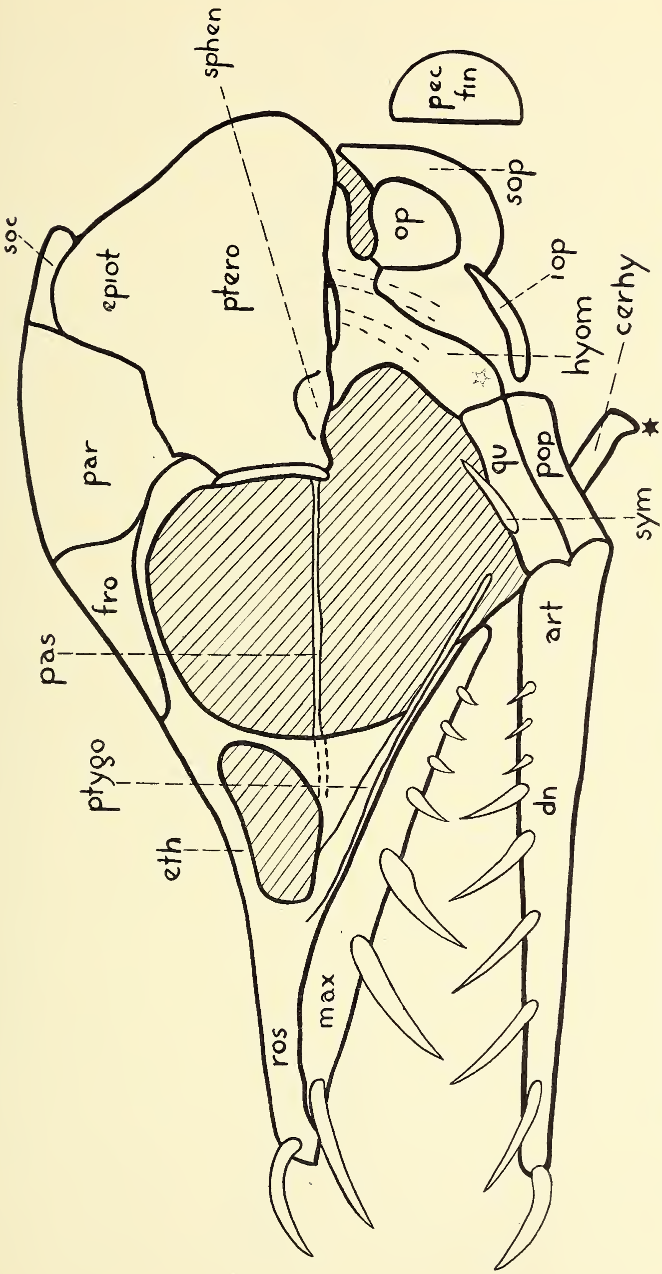


Fig. 14. *Nessorhamphus ingolfianus.* Skull of larva, standard length 28 mm.; lateral view. (x 42).

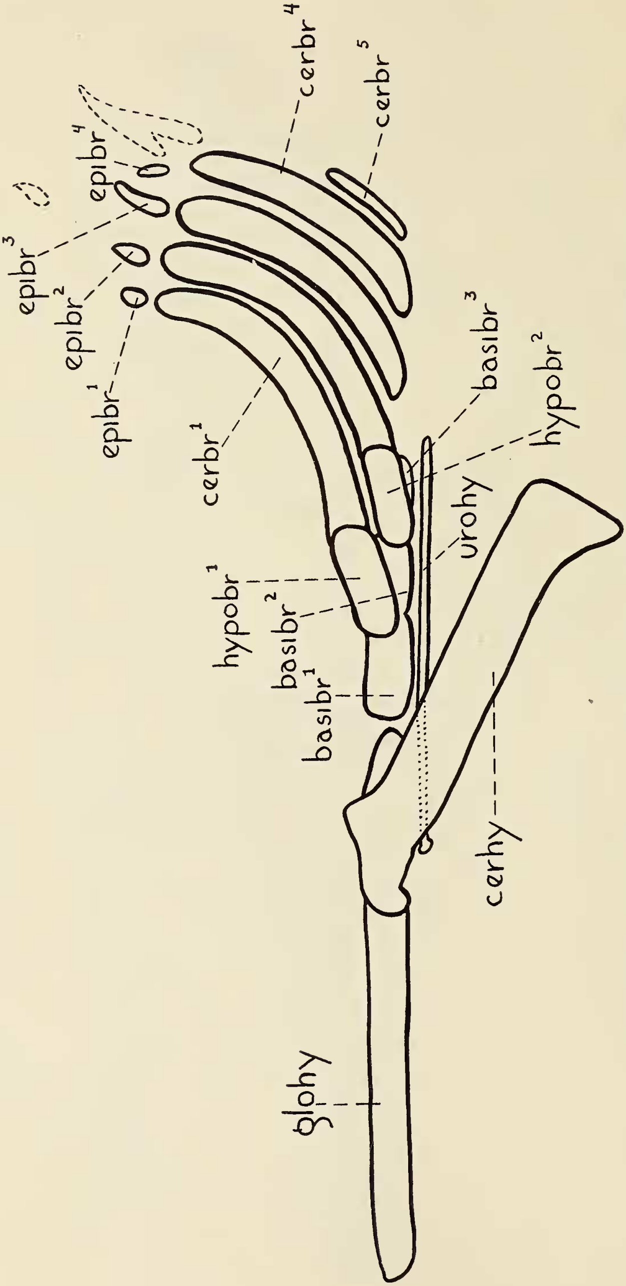


Fig. 15. ***Nessorhamphus ingolfianus.*** **Hyoid and branchial apparatus of larva, standard length 28 mm. (x 100).**

ADOLESCENT: In the adolescent stage the fins are in the same relative positions as in the transitional adolescent and adult; the body is less than half as deep as in preceding stages and a distinct thickening is apparent, although the general appearance is still distinctly leptocephaloid. All traces of larval pigment have disappeared, and permanent coloration is appearing on the tip of the snout, and, less densely, along its top and the crown of the head, beneath the outer epidermis. As Schmidt has remarked, in contrast to what is known in the case of many other eels, a distinct increase in length is apparent throughout metamorphosis. In his series, metamorphosing stages (corresponding to our post-larvae and adolescents) have a length of from 62 to 85 mm.; the youngest post-larva and most advanced adolescent in the Bermuda material measure respectively 70 and 81 mm.; a shrinkage of two or three millimetres at most seems to be all that takes place at any point in the development.

TRANSITIONAL ADOLESCENTS: The transitional adolescents, the "glass eels" of Schmidt, have the rounded, slender form of grown eels, but in this species pigment appears very gradually and late, and the full number of teeth—especially along the vomer proper—is only gradually attained. The largest Bermuda specimen, measuring 166 mm., appears almost white to the unaided eye, although it has all other adult characters with the exception of complete vomerine dentition (Fig. 12) and mature reproductive organs. Examination shows a dark spot on the tip of the snout, and fine chromatophores scattered over the head, jaws, cardiac and abdominal regions, the base of the anal fin, the base of the posterior half of the dorsal fin, and the end of the caudal peduncle; there is a fairly conspicuous, vertical band of dark brown across the middle of the caudal rays.

Osteology: The skeleton of a specimen of 142 mm. has been studied in detail, and compared both with younger examples of the Bermuda collection and with the 128 mm. specimen described and figured by Trewavas (1932). The latter differs from the present specimens chiefly in smaller epiotics.

In the youngest of the transitional adolescents examined, a specimen of 87 mm., the entire skeleton with the exception of the vertical finrays showed faint ossification, strongest on the jaws and weakest along the vertebral column. In the 148 mm.

example, ossification is much stronger throughout, with the exception of the sides and base of the brain-case, the coracoids and the radials, all of which show very faint stain, while the anterior dorsal finrays and all of the anal rays are entirely unossified.

Skull: (Figs. 16, 17). The most interesting characteristic of this region is the manner of the prolongation of the skull. Unlike the snouts of the comparable Nemichthyds, the lengthening has been brought about chiefly by the elongation of the frontals. The brain-case is perfectly oval. The epiotics occupy the posterior fourth of its dorsal surface. Anterior to these are the oblong parietals, twice as long as the epiotics in our specimens. The tiny supraoccipital is enclosed completely by the epiotics and parietals. The elongate pterotics form the major element of the sides of the brain-case. A sensory canal runs its full length, overlapping the frontal. The frontals are completely fused except anteriorly. About a third of their length is postorbital, forming the anterior fourth of the brain-case. At their posterior border their combined width is about equal to the length of this postorbital section. They narrow gradually, and are extremely narrow above the eyes, then broaden slightly to split at their junction with the ethmoid, the forked ends projecting into that bone laterally as far as the middle of the snout. In the Bermuda specimens there is no ossification of the spindle-shaped ethmoid anterior to the nostrils, although Trewavas shows a strong, compact ethmovomer.

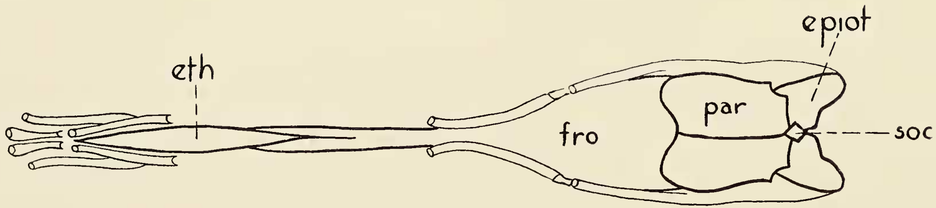
Palato-pterygoid Arcade: (Fig. 17). The hyomandibular in this species is an irregular quadrilateral with excavated sides. Its upper anterior angle articulates with the small, crescentic sphenotic arising from the pterotic, beneath the postero-lateral corner of the frontal. A broad wedge of the hyomandibular extends backward parallel with the pterotic, slightly beyond the edge of the brain-case, its apex forming the second angle of the quadrilateral. Diagonally opposite the sphenotic articulation a shorter arm joins the opercle. The fourth angle is formed by the typically hyomandibular arm which extends antero-ventrally to join the quadrate. The latter, connecting with the angular, is perfectly horizontal. The symplectic is large, equal to the quadrate in length and thickness; it lies above the quadrate and posteriorly overlaps the hyomandibular. The slender, rod-like pterygoid extends between the posterior part of the quadrate and the posterior portion of the vomer. There is no trace of a separate palatine. The vomer lies against the ventral surface of the ethmoid, broadening anteriorly and dipping ventrally to floor the bulbous snout tip. Between vomer and brain-case extends the strong and slender parasphenoid.

Jaw Apparatus: (Fig. 17). The slender maxillary originates at the posterior boundary of the swollen snout tip, ending close to the vertical from the posterior margin of the eye. Posteriorly it has a strong, downward curve. The strong dentary is notably shorter than the snout, its tip being even with that of the maxillary. It is slender anteriorly, with a slight expansion at the symphysis. Posteriorly it broadens considerably. The articular is of moderate size and clearly defined, although the angular boundaries are indeterminable.

Opercular Bones: (Fig. 17). All of the opercular bones are reduced and practically non-functional, as is usual in eels, lying far forward of the gill opening. The preopercle, lying distinct from and below the quadrate and hyomandibular, is slender and tubular, forming part of the mucous canal system. Below this, and extending beyond its posterior end, is the small interoperculum, and behind this a wiry suboperculum, lying immediately beneath the trapezoidal, oblong opercle, and curling up around its posterior end.

Mucous Canal Bones: (Fig. 18) In this system the pterotic canal dorsally and the preopercular and mandible ventrally, serve as correlative units. Near the posterior margin of the brain-case a small superficial tube links the preopercle with the pterotic and lateral line. Similar superficial bones, only partially ossified, surround the eye and extend dorsally and ventrally throughout the length of the snout, extending to its extreme tip, where a pair of small, terminal tubules lies between the ends of the upper and lower sets.

Hyoid Arch: (Fig. 19). The glossohyal is long, and ossified as far forward as the broadest portion of the dentary; posteriorly it almost reaches the vertical from the attachment of the opercle. The ceratohyals arise from the middle of this ossified portion. There is a hint in one of the Bermuda specimens of a division into basihyals and ceratohyals, the lines of demarcation



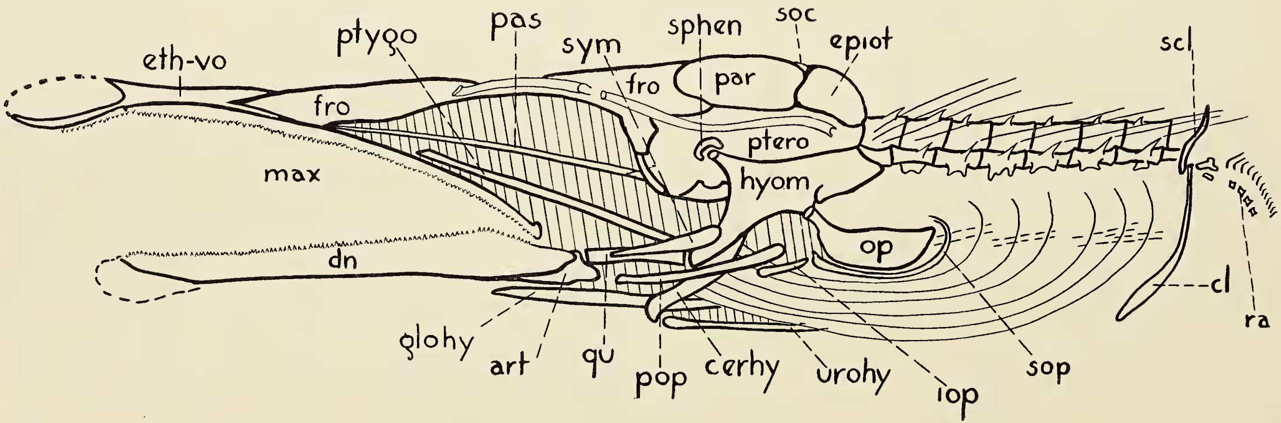
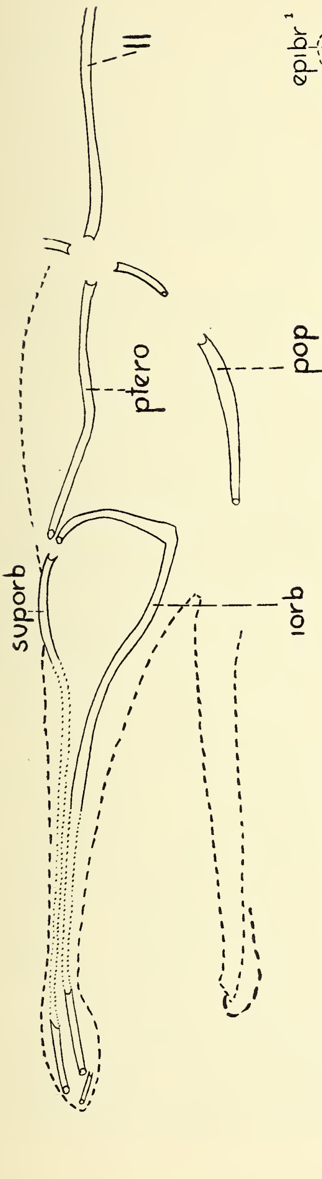


Fig. 16 (Upper). *Nessorhamphus ingolfianus.* Skull of transitional adolescent, standard length 142 mm.; dorsal view. (x 6.8).

Fig. 17 (Lower). *Nessorhamphus ingolfianus.* Bones of head, pectoral girdle and anterior part of vertebral column, in transitional adolescent, standard length 142 mm.; lateral view. (x 6.8).



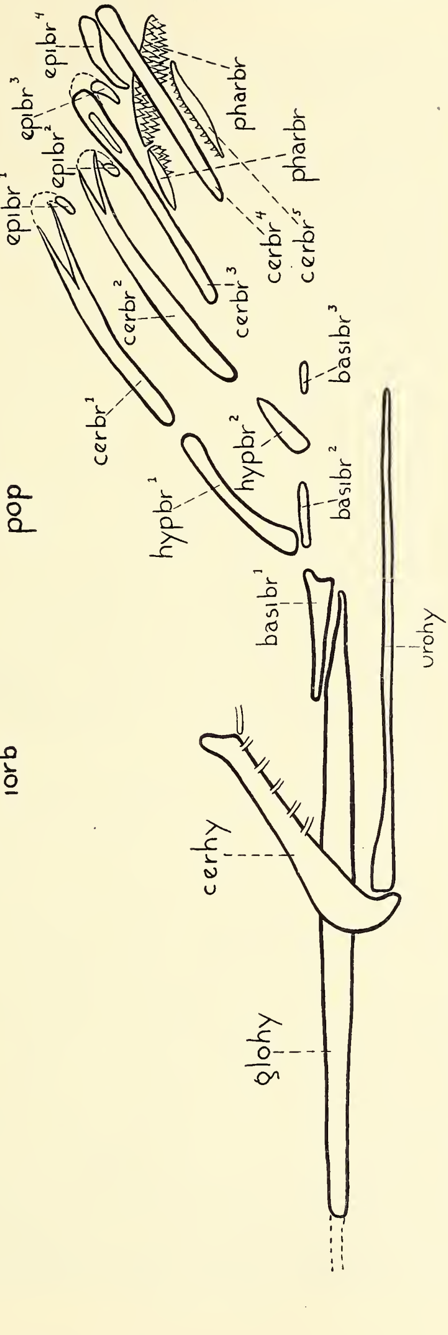


Fig. 18 (Upper). *Nessorhamphus ingolfianus.* Cephalic canal system in transitional adolescent, standard length 142 mm.; lateral view. (x 6.8).

Fig. 19 (Lower). *Nessorhamphus ingolfianus.* Hyoid and branchial apparatus in transitional adolescent, standard length 142 mm. (x 17.5).

falling between the first and second branchiostegal rays. There is no trace of separate epi- or interhyals. Articulation with the inner face of the hyomandibular is near the ventral border of the latter, about midway between quadrate and opercle. There are six or seven branchiostegals, the number sometimes varying on the two sides of the same specimen. These bones are always very slender, even basally, and only delicately ossified. Their posterior ends are curved forward, lying free in the branchial cavity. The last branchiostegal arises very close to the base of the preceding ray, and is only indirectly attached to the bone. A needle-like urohyal, its anterior end swollen, arises between the bases of the ceratohyals and extends posteriorly as far as the origin of the third gill arch.

Branchial Apparatus: (Fig. 19). The branchial arches lie between the posterior end of the opercle and the cleithrum, the bones lying almost horizontally, on a parallel with the upper edge of the opercle and overlapping each other throughout.

Three ossified, widely separated basibranchials show plainly in the Bermuda specimens. The first is triangular, the apex anterior, and lies against the upper surface of the attenuated end of the glossohyal. The second is slender and small, the third very small. The latter was completely lacking in Trewavas's example.

Hypobranchials are present in the first two arches, the second bone being half as long as the first. All five ceratobranchials are well developed, the first four of equal size—as long as the ceratohyal, but more slender—the fifth only half as long. The first two are deeply forked at their postero-dorsal tips, and their whole central regions scarcely ossified; the third is closed distally, but has an oblong terminal foramen; the fourth is fairly well ossified throughout, while the small fifth ceratobranchial is the strongest of all and bears an irregularly double series of conical teeth. There are four epibranchials, the first two minute and oval, the third long, and the fourth elongate and altogether more than five times as large as the first. Two pharyngobranchials are practically joined by suture, lying internal and immediately ventral to the third and fourth epiotics. Their dentigerous surfaces are opposed to the corresponding face of the fifth ceratobranchial. The anterior pharyngobranchial has only about half a dozen teeth, all confined to its postero-ventral surface; the other bone, however, has one entire surface covered with about forty conical teeth, arranged in roughly diagonal rows of seven or eight teeth each.

Pectoral Girdle: (Fig. 17). The doubly-curving supra-cleithrum is placed at the level of the anterior part of the eighth vertebra, with which, however, it has no direct connection. The cleithrum continues the girdle ventrally, curving forward in its lower portion. Both bones, though slender, are strongly ossified. Between the upper end of the cleithrum and the uppermost pectoral finray are two tiny disks of bone, only partially ossified, the hyper- and hypocoracoids. Four minute radials are visible, with only traces of ossification. Only the anterior, upper eleven of the thirteen pectoral rays have bony deposits, and these throughout only their proximal portions.

Vertical Fins and Supports: (Fig. 20). The dorsal fin originates between the 17th and 18th vertebrae, the anal at the 75th. Only the proximal halves of the dorsal rays are ossified, and even here the stain dies out toward the end of the fin. The anal rays are entirely unossified. Baseosts of both fins are well developed and stained, though less strongly in the case of the anal supports. The same is true of the radials connecting the finrays. These minute, horizontal bones must serve the same purpose, in aiding the forward migration of the vertical fins during metamorphosis, as do the analagous elements in the quite unrelated *Idiacanthus* (Beebe 1934, p. 213). There are usually two finrays to each vertebra.

Vertebral Column: (Fig. 20). The count of 150 vertebrae for the largest cleared-and-dyed specimen includes both the first element, which is fused to the skull, and the urostyle. Ossification is strong only toward the end of the column. The vertebrae are all of similar length (about .8 mm.) as far back as the 135th element. Posterior to this they decrease in size and the last form the specialized support for the caudal fin (see p. 45).

The dual character of the column—its formation around the original neural tube and notochord—is very evident in this species, and particularly in the immature specimen under discussion. Each centrum of typical, hour-glass, adult shape, is attached by distinct suture to the exceedingly large, parallelo-

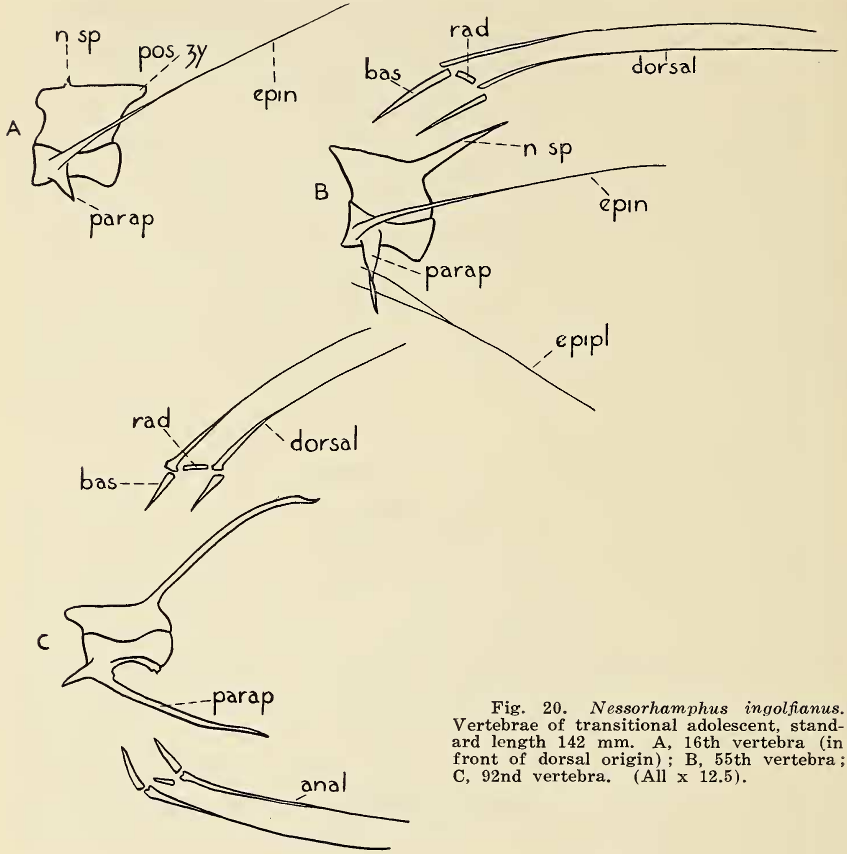


Fig. 20. *Nessorhamphus ingolfianus.* Vertebrae of transitional adolescent, standard length 142 mm. A, 16th vertebra (in front of dorsal origin); B, 55th vertebra; C, 92nd vertebra. (All x 12.5).

grammatic neuropophysis, this element equalling or exceeding the centrum in height.

The neural arches slope backwards and upwards in the first sixteen or seventeen vertebrae, the neural spine being small and near the anterior end of the arch. Posterior to this, the direction of the slope is reversed, and the neural spine shifts gradually to the posterior end of the arch, increasing progressively in size backward.

The first vertebra gives rise to three epineurals on the left side of the Bermuda specimen, and, possibly, on the right side also; Trewavas shows two in her figure. These extra elements may be vestiges of former vertebrae. Posterior to the pectoral fin the epineurals are forked proximally. They die out at about the 124th vertebra. Throughout the length of the fish each epineural measures about three times as long as a centrum.

The centrum of the first vertebra is very short and lacks parapophyses. Between this and the pectorals the parapophyses are small and widely separated by median lamellar projections of irregular shape. Behind the pectorals the parapophyses become longer and more ventral, and arise directly from the lamellae, which are found in more lateral positions. From the dorsal origin backward the parapophyses shift gradually to the forward end of the centra, and each lamella extends the full length of the centrum, forming anterior and posterior zygopophyses toward the end of the caudal peduncle.

There are no pleural ribs.

Epipleurals are traceable from the 40th (37th in Trewavas's specimen) vertebra to the 124th, the same point at which the epineurals vanish. They are of similar length, and are forked proximally.

Posterior Part of Vertebral Column and Caudal Fin: (Fig. 21). There is remarkably little specialization of precaudal vertebrae up to the very urostyle segment itself. What change there is consists altogether of size, the individual vertebrae becoming gradually smaller from the 144th or seventh precaudal, which measures .54 mm. in length, to the 150th or last before the urostyle, which is only .24 mm. in length. The rounded articulating anterior part of the urostyle segment gives rise at once to a bony urostyle, longer than any of the precaudal vertebrae. This supports a well-developed neural arch, closely approximating in size and shape that of the precaudal elements.

From the ventral side of the urostyle arise three bony bases for the hypurals. The most superior one flares out into a fan shape, whose truncate posterior aspect supports the upper six of the twelve caudal rays. The second and third bases arise as stout pillars, and fuse over their posterior ends enclosing a large oval foramen. This entire plate supports four more of the rays. A fourth hypural articulates at its base with the prolonged haemal arch of the 150th vertebra, and an inferior facet of the third hypural base. The slightly expanded tip of this hypural

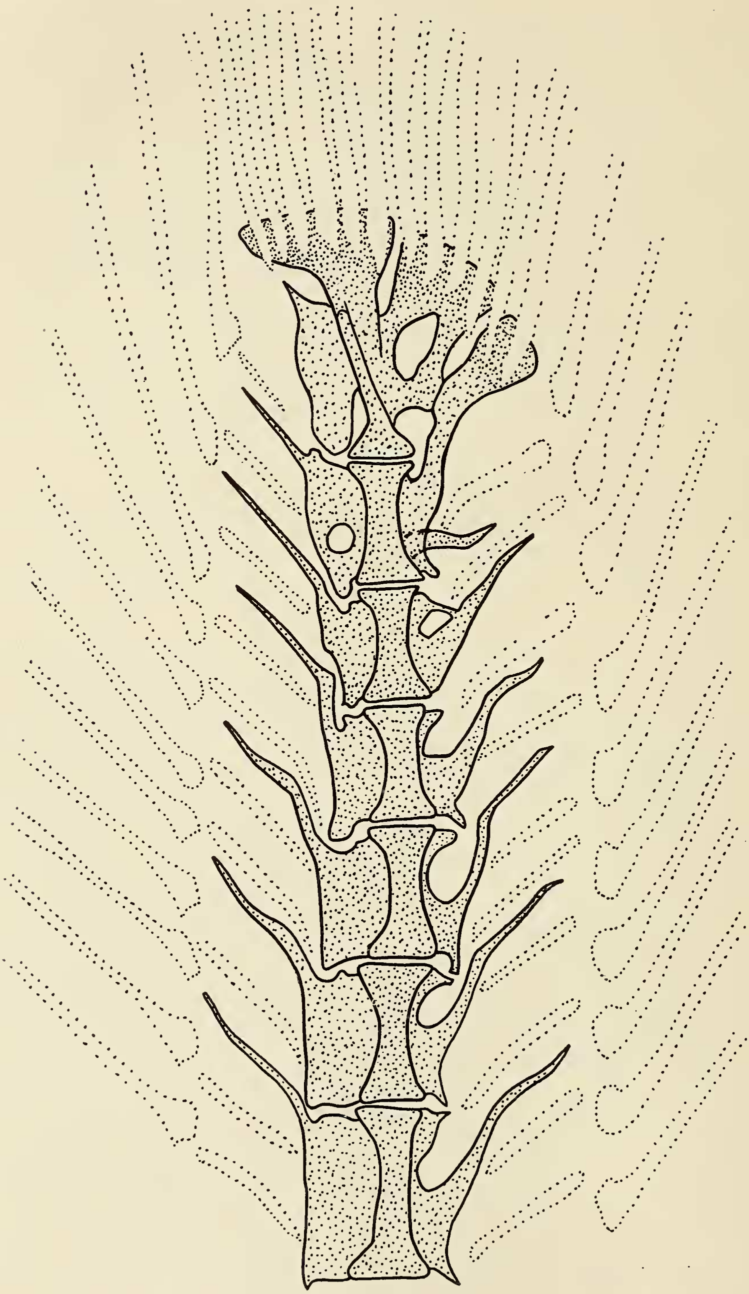


Fig. 21. *Nessorhamphus ingolfianus.* End of vertebral column and base of caudal fin of transitional adolescent, standard length 142 mm. (x 58).

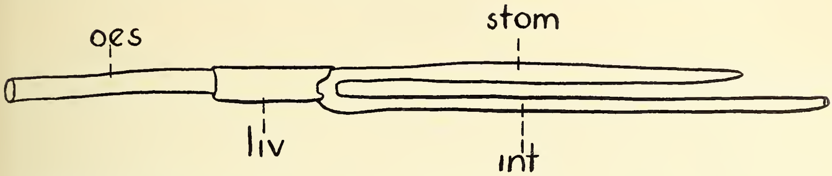


Fig. 22. *Nessorhamphus ingolfianus.* Alimentary canal of transitional adolescent, standard length 142 mm. (x .8).

supports the last two of the twelve caudal rays. All of these rays are strongly ossified for a considerable distance.

Digestive System: (Fig. 22). This is of the simplest. The blind sac stomach in our largest transitional adolescents is unpigmented and falls short of the anus. The pylorus is a snout's length behind the level of the pectoral base, at the posterior end of the single-lobed liver. The anterior end of the liver lies only several millimetres behind the pectoral base. The gall bladder is small and is placed immediately anterior to the pylorus.

Urino-genital System: The kidneys are uniformly slender and extend the full length of the coelomic cavity. They contain pigmented matter similar to that commonly found in these organs in certain families of this group.

The gonads are rudimentary, and appear as slender threads along the roof of the coelom.

RELATIVE BODILY PROPORTIONS: The following table shows the relative proportions of *Nessorhamphus* at different ages:

Growth Stage	Length / Depth	Length / Head	Head / Eye	Head / Snout	Length / Snout to Dorsal	Length / Snout to Anal	Pre-anal Myomeres
Larva (26, 28 mm.) (Present Series)	7.—7.8	8.6—9	6.5—5.8	2.1—2.2	1.8	1.1	120-121
Post-larvae (68 to 72 mm.) (Present Series)	7.4—9.6	8.5—7.4	8.2—9.7	2.5—2.2	4.4—4.8	1.5—1.7	89-78
Adolescents (81, 78 mm.) (Present Series)	18.—20.	7.8—6.4	7.4—8.7	2.—2.2	5.	1.8	72-73
Transitional Adolescents (80 to 166 mm.) (Present Series)	29.5—30.	6.2—6.	9.5—10.7	2.6—2.5	4.8—4.6	1.9—1.8	72-73
Adult (248.5 mm.) (Type Specimen)	25.	7.2	10.6	2.4	4.8	1.8	72 (vertebrae)

Ecology

Seasonal and Vertical Distribution: According to Schmidt, *Nessorhamphus ingolfianus* spawns at or near the surface of the Sargassum Sea in spring and early summer, somewhat later in the east than in the west, and the metamorphosis of the larva takes place in August, September and October at lower levels. The present material lends corroboration. In the spring only large transitional adolescents were captured off Bermuda; no small larvae have been taken there, the only larvae of any length being two half-grown leptocephali caught early in September; finally, all of the metamorphosing specimens occurred in August and September, in deep water.

Abundance: *Nessorhamphus* is rare among the deep-sea fish captured off Bermuda, only once occurring in every 52.5 nets drawn between 400 and 1,000 fathoms, the Bermuda limits of its distribution.

Sociability: Only twice were more than a single specimen taken in the same net; in each of these cases two transitional adolescents of similar size came up together.

Food: The stomachs of six transitional adolescents, between 87 and 166 mm., were found to contain remains of schizopods or shrimps. These were distributed as follows:

Length of Nessorhamphus	*Food*	*Length of Food*
85 mm.	1 *Thysanopoda*	20 mm.
87 mm.	1 *Thysanopoda*	11 mm.
88 mm.	1 shrimp or schizopod; much digested.	
125 mm.	3 *Thysanopoda*	17 to 23 mm.
141 mm.	3 Shrimps or schizopods; small; much digested	
166 mm.	1 *Sergestes*	31 mm.

In every case the crustaceans had been swallowed tail first. An 80 mm. specimen had eaten radiolarians.

Enemies: *Nessorhamphus* has not yet been found in the stomach of any other animal.

Viability: We have not taken *Nessorhamphus* alive in our nets. Captain Hansen and Dr. Tåning, however, both succeeded in hatching the eggs on board ship, and in raising the pre-larvae to a stage where comparison could be made with pre-larvae of known identity caught swimming in the water.

Study Material

The following list gives the catalogue number, depth in fathoms, date of capture, length and growth stage of each specimen of *Nessorhamphus ingolfianus* taken by the Bermuda Oceanographic Expeditions. All were caught in the cylinder of water off the Bermuda coast described in Zoologica, Vol. XVI, No. 1, p. 5. "Trans. Adol." stands for "Transitional Adolescent."

No. 9,568; Net 24; 700 F.; April 15, 1929; 125, 135 mm.; Trans. Adol.
No. 9,751; Net 64; 600 F.; May 4, 1929; 141 mm.; Trans. Adol.
No. 12,499; Net 385; 600 F.; Aug. 17, 1929; 70 mm.; Post-larva
No. 13,561; Net 460; 700 F.; Sept. 11, 1929; 88 mm.; Trans. Adol.
No. 16,030; Net 707; 500 F.; June 16, 1930; 142 mm.; Trans. Adol.
No. 17,748; Net 834; 400 F.; Sept. 3, 1930; 85 mm.; Trans. Adol.
No. 17,819; Net 842; 600 F.; Sept. 4, 1930; 78 mm.; Adolescent
No. 18,024; Net 855; 700 F.; Sept. 6, 1930; 92 mm.; Trans. Adol.
No. 18,058; Net 859; 500 F.; Sept. 8, 1930; 69 mm.; Post-larva
No. 18,082; Net 861; 700 F.; Sept. 8, 1930; 68 mm.; Post-larva
No. 18,601; Net 890; 600 F.; Sept. 15, 1930; 80 mm.; Trans. Adol.
No. 19,274; Net 940; 1,000 F.; Sept. 24, 1930; 81 mm.; Adolescent
No. 23,041; Net 1,245; 1,000 F.; Aug. 31, 1931; 70 mm.; Post-larva
No. 23,126; Net 1,263; 800 F.; Sept. 4, 1931; 28 mm.; Larva
No. 23,292; Net 1,287; 1,000 F.; Sept. 10, 1931; 26 mm.; Larva
No. 23,550; Net 1,312; 400 F.; Sept. 16, 1931; 72 mm.; Post-larva
No. 23,565; Net 1,313; 500 F.; Sept. 17, 1931; 87, 87 mm.; Trans. Adol.
No. 23,600; Net 1,314; 600 F.; Sept. 17, 1931; 166 mm.; Trans. Adol.
No. 23,636; Net 1,324; 400 F.; Sept. 18, 1931; 84 mm.; Trans. Adol.

Synonymy and References

Leptocephalus ingolfianus:

Schmidt, 1912, p. 49, pl. III, fig. 8. (Description of larva).

Avocettina scapularostris:

Borodin, 1929, p. 109. (1 specimen; 153 mm.; 41° 29′ N. Lat., 47° 48′ W. Long.; 800-0 fathoms).

Borodin, 1931, p. 74, pl. 3, figs. 1-3. (Supplementary description of preceding specimen).

Nessorhamphus ingolfianus:

Schmidt, 1930, p. 273, pls. IV-V. (Type description; résumé of development. Many thousand specimens from North Atlantic, surface to deep water, in collection; eggs and fish of all lengths up to at least 248.5 mm.).

Trewavas, 1932, p. 652, pl. IV, text figs. 7-9. (Osteology).

Parr, 1932, p. 19. (1 specimen; 125 mm.; 23° 24′ 15″ N. Lat., 64° 29′ W. Long.; 10,000-foot wire).

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1932 Bermuda Oceanographic Expeditions 1931. Individual Nets and Data. Zoologica, Vol. XIII, No. 3.

1933a Deep-sea Fishes of the Bermuda Oceanographic Expeditions. Introduction. Zoologica, Vol. XVI, No. 1.

1933b Deep-sea Fishes of the Bermuda Oceanographic Expeditions. Family Alepocephalidae. Zoologica, Vol. XVI, No. 2.

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